

Heat Recovery from Sedimentary Formations

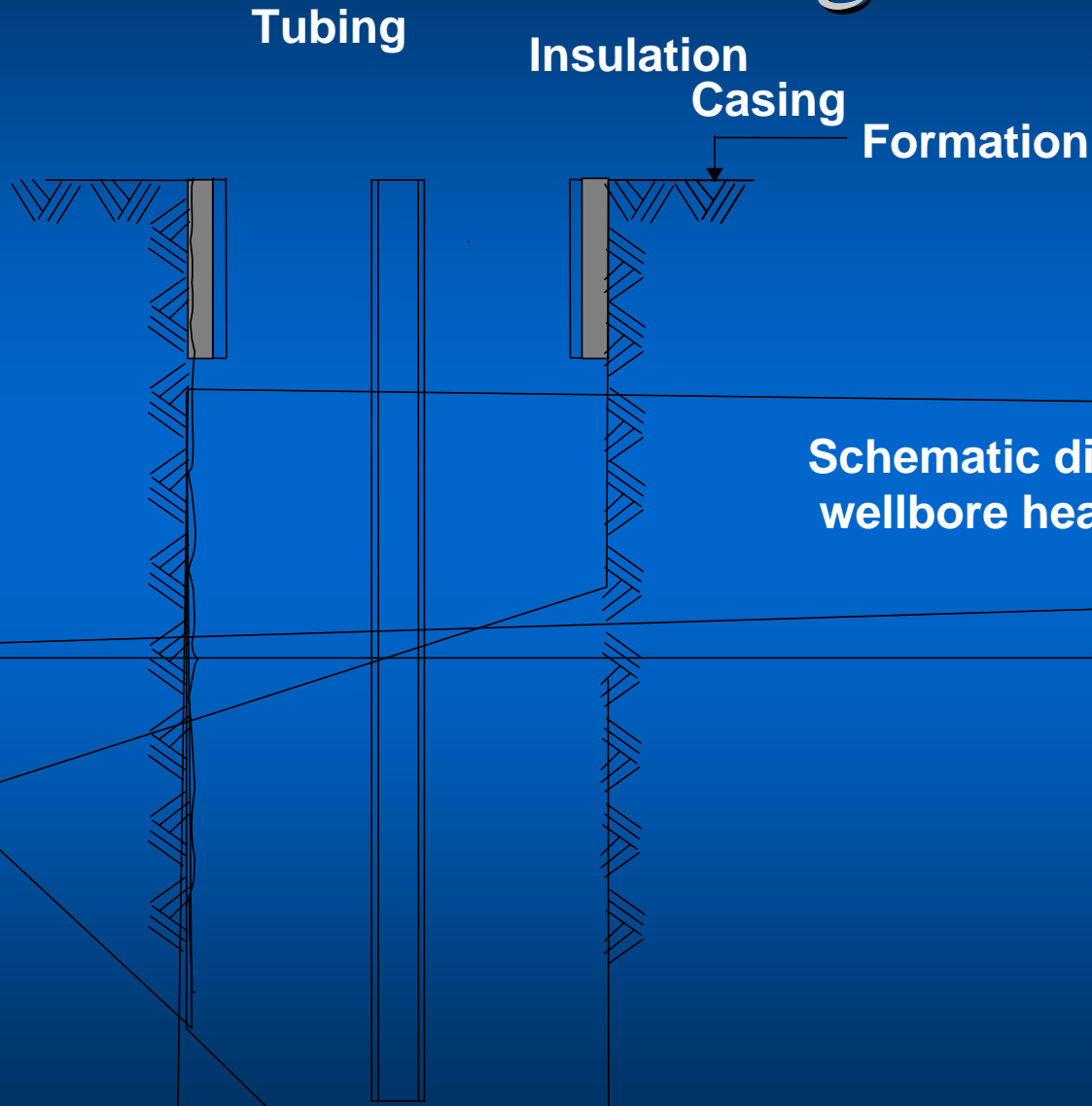
G. Michael Shook,
Idaho National Engineering & Environmental Laboratory
ChevronTexaco ETC

Motivation

- **Studies show surface area for heat transfer crucial to energy production**
 - Sediment A >> Fracture A
- **Existing infrastructure reduces cost**
 - Wells, Separators, Reinjection
- **Potential to extend “EGS” to 6-10 new states**

Summary of Cases Studied

Wellbore Heat Exchanger Model



Schematic diagram of the wellbore heat exchanger

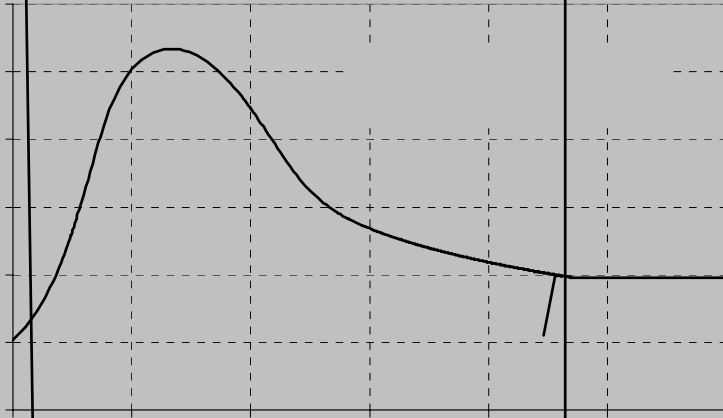
Parametric Sensitivity Study

- ' **Circulation Rate**
- ' **Wellbore diameter**
- ' **Tubing properties**
- ' **Working fluid properties**
- ' **Heat flux / wellbore depth**
- ' **Formation types**

Optimal Parameters from Studies

- ' **Circulation Rate** \emptyset **100 gpm**
- ' **Wellbore diameter** \emptyset

Best Case Results



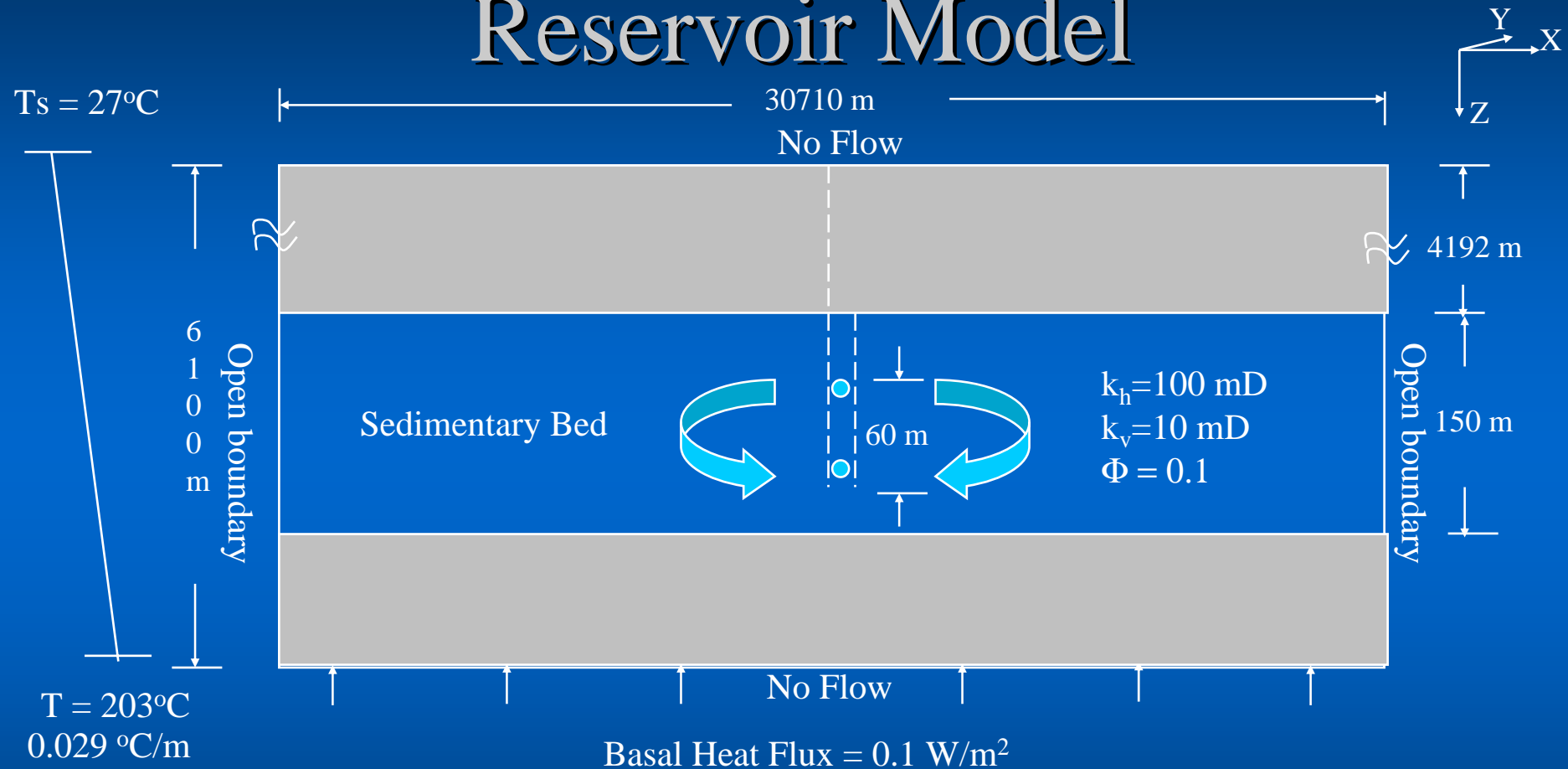
Summary and Conclusions

- **Comprehensive sensitivity study conducted**
- **Best Case below existing plant performance**
- **Wellbore heat exchanger not viable even with ideal energy conversion**

Engineered Geothermal Systems using Advanced Well

Vertical Well Dual Perforation (DP) System

Reservoir Model



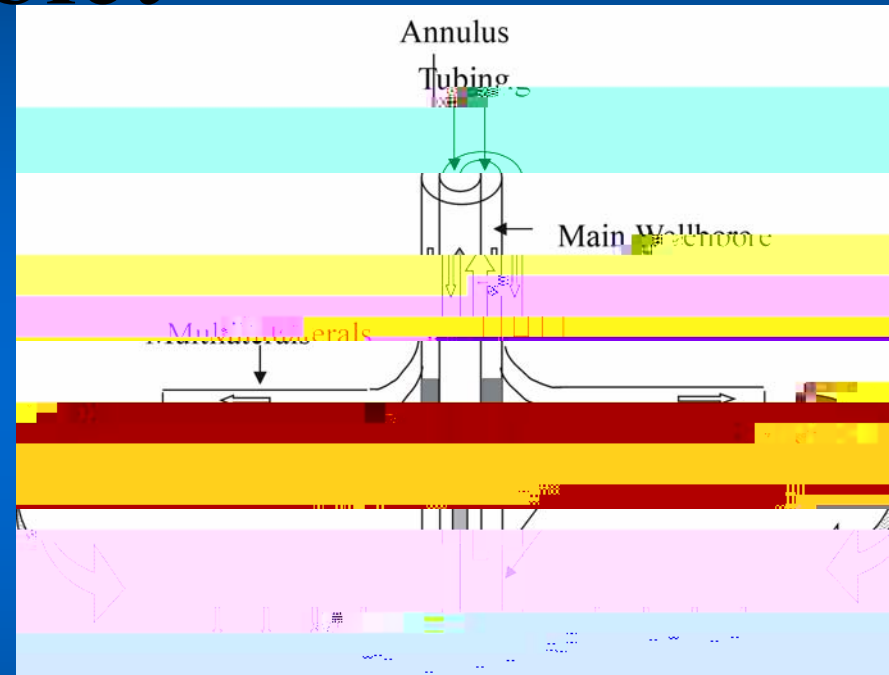
- **Circulation rate = 6.31 kg/s**
- **Injection Temperature = 27°C**

Vertical Well Dual Lateral Doublet

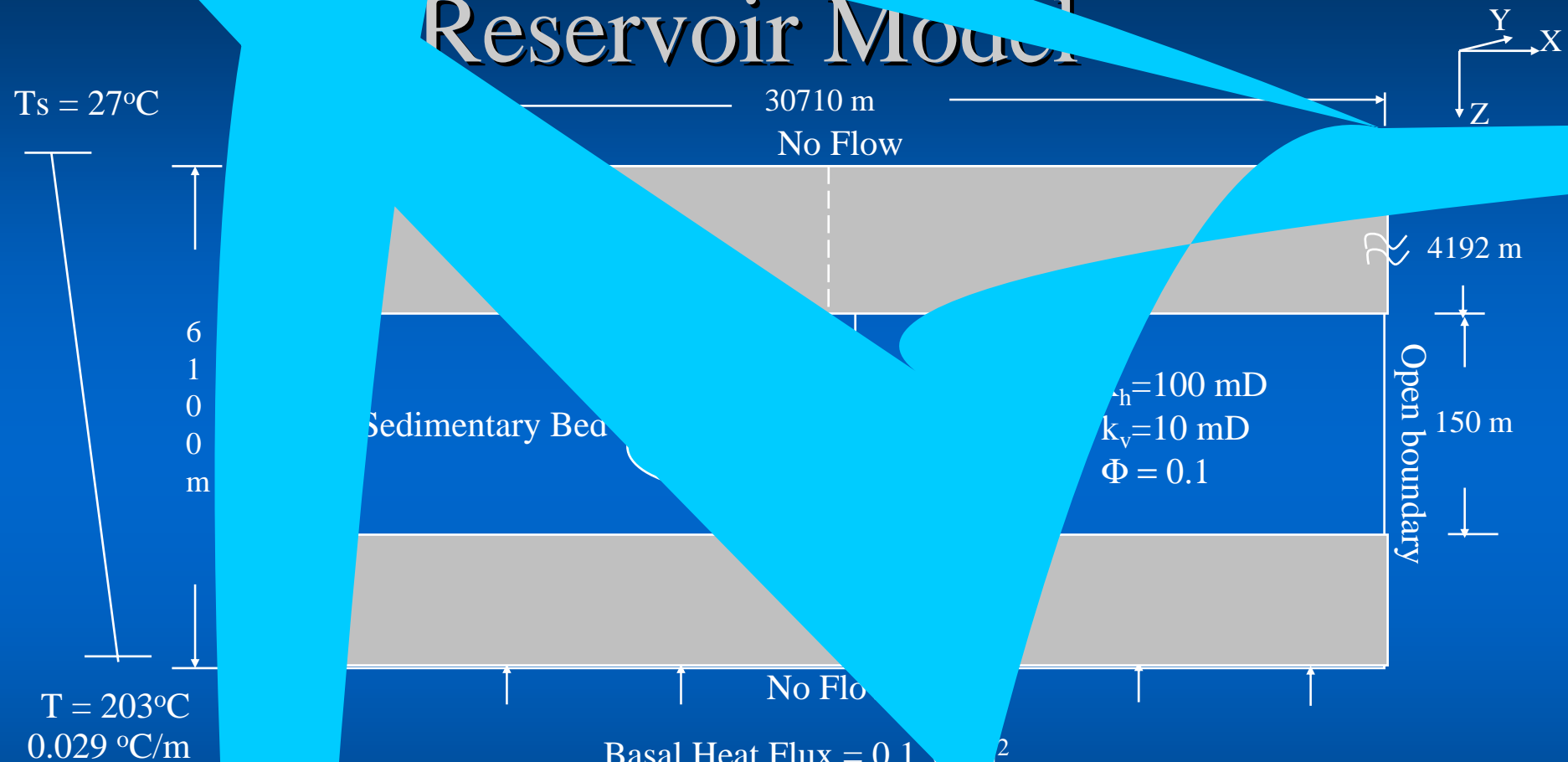
Geometry

- Vertical well
- Dual lateral doublet

Improved wellbore productivity and increased reservoir exposure



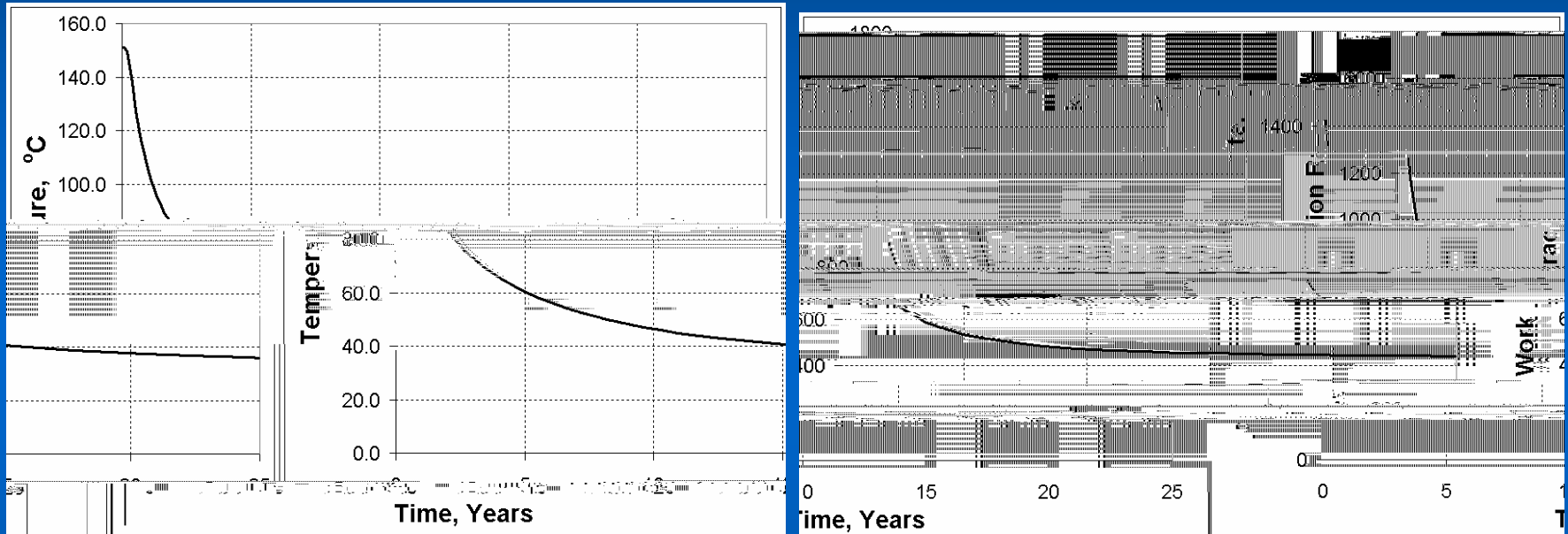
Reservoir Model



Circulation rate = 6.31 kg/s

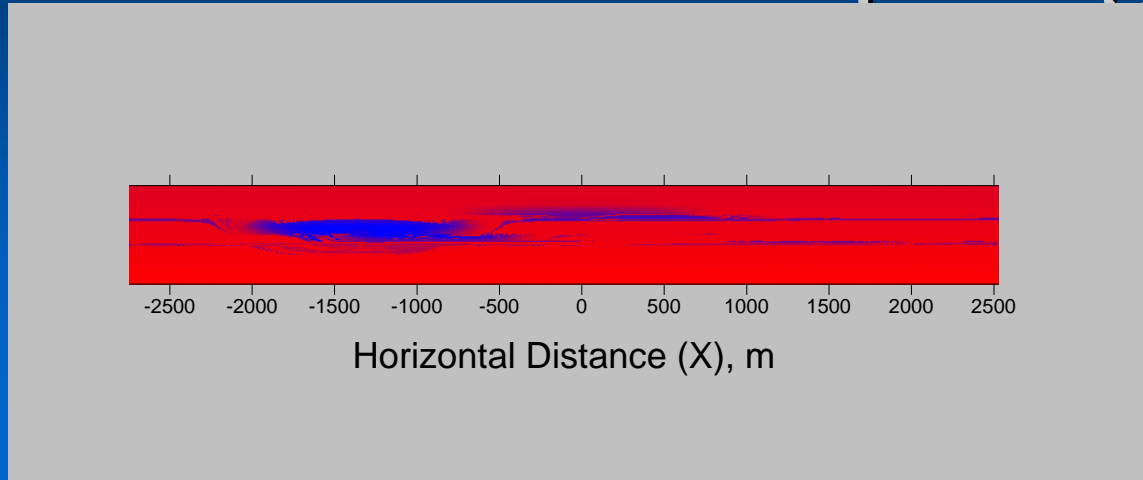
Injection Temperature = 27 °C

Best Case Dual Lateral Doublet Results



- Best case – Extraction Temperature : 60.4°C & Ideal Work Rate : 536 kW at 5 yrs
- Doesn't incorporate the temperature gain by conduction while flowing down
- Better technology than Dual Perforation for EGS

Thermal/Fluid Swept Region



Summary & Conclusions

Advanced Well Technologies Evaluation

- Preliminary study conducted
- Potential means of achieving EGS goals

Vertical Well Dual Perforation System

- Limited by sedimentary bed thickness

Vertical Well Dual Lateral Doublet System

- Better than Dual Perforation System but still limited sedimentary bed thickness

Horizontal Wells

- Unconstrained spacing à longer residence times, more rock-fluid contact area and higher temperatures
- Horizontal well multilateral doublet is promising technology for EGS

Single Well Energy Production

Xina Xie

K. Kit Bloomfield

Greg Mines

G. Michael Shook

Governing Equations

- Single Phase, PSS, inflow equations
- Pump efficiency and parasitic load

$$P_I - P_{wf} = \frac{q\mu}{2\pi kh} \frac{1}{2} \ln \frac{4A}{\gamma C_A r_w^2} + \frac{2\pi kt}{\phi\mu cA} + S$$

Example of Analysis Results

Depth = 6 km

– $T = 175^{\circ}\text{C}$

Reservoir properties

– $r_e = 4000 \text{ m}$ ($V_p = 250 \text{ E6 m}^3$)

– $k > 50 \text{ md}$

– $h = 25 \text{ m}$

$\Delta P = 540 \text{ Bar}$

– $P_I = 1005 \text{ bar}$

– $\cong P_{HS} \text{ at } 12 \text{ km}$

Injection/Extraction Energy Production

- ' **Primary production**
 - Offshore production platforms
- ' **Watered out (mature) fields**
- ' **Ongoing waterfloods**

